LEVEL II

OSAGE - GASCONADE BASIN

WILLIAM HAYES LAKE DAM

BENTON COUNTY, MISSOURI

MO 31052

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

DECEMBER 1979

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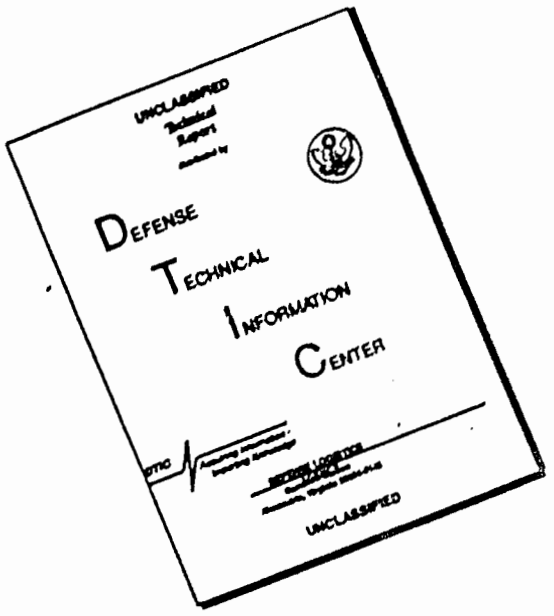

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: William Hayes Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the William Hayes Lake Dam (MO 31052).

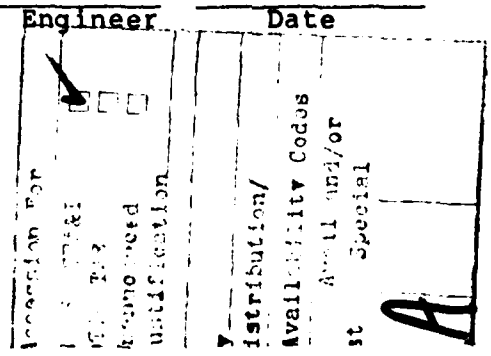
It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood
2) Overtopping could result in dam failure
3) Dam failure significantly increases the hazard to loss of life downstream

SUBMITTED BY: SIGNED 31 MAR [illegible]
Chief, Engineering Division Date

APPROVED BY: SIGNED 1 APR 1980
Colonel, CE, District Engineer Date



WILLIAM HAYES LAKE DAM

BENTON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31052

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared by

Anderson Engineering, Inc. Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction of

St. Louis District, Corps of Engineers

For

Governor of Missouri

March, 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	William Hayes Lake Dam
State Located:	Missouri
County Located:	Benton County
Stream:	Tributary to Lake of the Ozarks
Date of Inspection:	6 September 1979

William Hayes Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately one half mile downstream of the dam. Located within this zone are several dwellings. The dam is in the small size classification, since it is greater than 25 ft. high but less than 40 ft. high, and the maximum storage capacity is greater than 50 acre-ft. but less than 1000 acre-ft.

Our inspection and evaluation indicates that the combined spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 25 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of

small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the small volume of water impounded, and the height of the dam, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The 100-year frequency flood will not overtop the dam. The 100-year flood is one that has a 1 percent chance of being equalled or exceeded in any given year.

Deficiencies visually observed by the inspection team were: (1) lack of wave protection along the entire front face of dam; (2) heavy weed growth on front face of dam; (3) weeds and concrete block around primary spillway inlet; (4) erosion at east embankment-abutment contact; (5) seepage areas at downstream toe beyond primary spillway outlet; and (6) small amount of water coming out of primary spillway outlet even though there was no flow over the spillway crest. Another deficiency was the lack of seepage and stability analysis records.

It is recommended that the owners take the necessary action in the near future to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

John M. Healy, P.E.
Hanson Engineers, Inc.

Steven L. Brady, P.E.
Anderson Engineering, Inc.

Tom Beckley, P.E.
Anderson Engineering, Inc.

Gene Wertepny, P.E.
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AERIAL VIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

WILLIAM HAYES LAKE DAM - ID No. 31052

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APPENDICES

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of William Hayes Lake Dam in Benton County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

William Hayes Lake Dam is an earth fill structure approximately 32 ft. high and 360 ft. long at the crest. The appurtenant works consist of an 18 in. diameter primary spillway pipe with 30 in. diameter riser pipe, a four in. diameter drawdown pipe with a four in. gate valve connection to a two in. diameter gate valve and an emergency spillway cut into natural ground in the east abutment. Sheet 3 of Appendix A shows a plan, profile and typical section of the embankment.

B. Location:

The dam is located in the central part of Benton County, Missouri on a tributary of Lake of the Ozarks. The dam and lake are within the Edwards , Missouri 7.5 minute quadrangle sheet (Section 14, T40N, R21W - latitude 38 14.9'; longitude 93 14.3'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 32 ft. and a maximum storage capacity of approximately 80 acre-ft., the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately one half mile downstream of the dam. Located within the damage zone are several dwellings.

E. Ownership:

The dam is owned by Mr. and Mrs. William Hayes. The owners' address is Warsaw, Missouri 65355. (Telephone number is 816-438-6367)

F. Purpose of the Dam:

The dam was constructed primarily for recreational purposes.

G. Design and Construction History:

The dam was designed by the United States Department of Agriculture, Soil Conservation Service. Design plans and notes were obtained from the SCS office in Warsaw, Missouri, and are included in Appendix A. The dam was constructed over a two year period by Mr. Hayes and completed in 1975. During the construction period Mr. Dan Philbrock of the SCS office in Warsaw supervised the construction of the dam. A trench 15 to 20 ft. deep was excavated to solid bedrock. Borings were taken along the length of the core to check for rock ledges. A layer of bentonite was placed in the bottom of the trench after the remaining soil material was swept off the bedrock. The material for the cutoff trench was obtained from the lake area. Bedrock was exposed during exca-

vation in the lake area. Material was spread over the exposed area and compacted. After the filling and compaction operation reached an elevation above the proposed top of spillway pipe, a trench was cut across the crest and down the embankment and the spillway pipe was then placed in the trench. The material surrounding the pipe was then hand tamped. Three anti-seep collars were installed on the 18 in. spillway pipe. Drainage into the lake area during the construction of the dam was removed via the four in. drain pipe. After the lake began filling, a two in. gate valve was connected about two ft. downstream from the four in. gate valve due to leakage through the four in. valve. A two in. diameter pipe extends the outlet for the drawdown system about 20 ft. downstream of the embankment toe.

All of the information listed above was furnished by Mr. William Hayes, the owner of the dam.

H. Normal Operative Procedures:

Normal flows are to be passed by an uncontrolled 30 in. CMP drop inlet through an 18 in. CMP outlet near the center of the dam. Excess flows are passed by the emergency spillway in the east abutment. Mr. Hayes stated that the maximum pool elevation was about one foot above the primary spillway inlet.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is approximately 92 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through uncontrolled spillways. Rating curves were developed assuming a combination of Weir and pipe flow for the primary spillway and critical flow for the emergency spillway section.

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 734.1 ft., MSL): 100 cfs

(3) Estimated Capacity of Primary Spillway: 23 cfs

(4) Estimated Experienced Maximum Flood at Dam Site: Elevation 730.5 , 17 cfs

(5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable

(7) Gated Spillway Capacity at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

(All elevations are consistent with an estimated MSL elevation of 730.0 for the top edge of the 36 in. drop inlet.)

(1) Top of Dam: Low Point: 734.1 , High Point: 734.5

(2) Principal Spillway Crest: 730.0

(3) Emergency Spillway Crest: 732.4

(4) Principal Outlet Pipe Invert: 705.7

(5) Streambed at Centerline of Dam: 702.7

(6) Pool on Date of Inspection: 729.1 (0.9 ft. below normal pool)

(7) Apparent High Water Mark: 730.5

(8) Maximum Tailwater: Unknown

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 1080 ft.

(2) At Principal Spillway Crest: 1000 ft.

(3) At Emergency Spillway Crest: 1050 ft.

E. Storage Capacities:

(1) At Principal Spillway Crest: 54 Acre-ft.

(2) At Top of Dam: 80 Acre-ft.

(3) At Emergency Spillway Crest: 69 Acre-ft.

F. Reservoir Surface Areas:

(1) At Principal Spillway Crest: 5.9 Acres

(2) At Top of Dam: 7.3 Acres

(3) At Emergency Spillway Crest: 6.7 Acres

G. Dam:

(1) Type: Earth

(2) Length at Crest: 360 ft.

(3) Height: 32 ft.

(4) Top Width: 12 ft.

(5) Side Slopes: Upstream slope to water edge is 2.46H:IV; Downstream Varies from 2.68H:IV & 3.31H:IV. (See Sheet 3, Appendix A).

(6) Zoning: Homogeneous

(7) Impervious Core: None

(8) Cutoff: According to Mr. William Hayes a trench 15 to 20 ft. deep was cut down to bedrock. The trench was filled with compacted clay after placing a layer of bentonite on the bedrock surface.

(9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

(1) Type: Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Principal Spillway:

(1) Location: Near the center of the dam at Sta. 2+00

(2) Type: 30 in. CMP drop inlet riser pipe with an 18 in. CMP through the embankment.

I.2 Emergency Spillway:

(1) Location: East abutment

(2) Type: Earth Channel

I. Regulating Outlets:

A four in. diameter pipe with a four in. gate valve connecting to a two in. gate valve with a two in. diamter outlet pipe.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

Design notes of the embankment are available from the Department of Agriculture Soil Conservation Service Office at Warsaw, Missouri. Copies of these notes are included in Appendix A and hydraulic calculations are included in Appendix C. No documentation of construction inspection records have been obtained. To our knowledge there are no documented maintenance and operation data.

A. Surveys:

A site suvey conducted by the SCS before the dam was built was copied from a drawing in the Warsaw Office and is included in Appendix A. The top edge of the 30 in. primary spillway riser was used as datum for our survey. From photographs and quad sheets the elevation was estimated to be 730.0 ft. mean sea level elevation.

B. Geology and Subsurface Materials:

The site is located in the Western edge of the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus and deep valleys. The most common bedrock types are dolomite, sandstone and chert. Information supplied by the Missouri Geological Survey indicates that the lake area is underlain by the Roubidoux formation of the Canadian Series in the Ordovician System. The Roubidoux formation consists of sandstone, dolomitic sandstone and cherty dolomite. The publication "Caves of Missouri" lists two caves known to exist in Benton County. These caves are several miles from the site.

The "Geologic Map of Missouri" indicates the nearest fault to be approximately 20 miles east of the site. The Missouri Geological Survey has indicated that the faults in this area are generally considered to be inactive and have been for several hundred million years (rock associated with the Ordovician Period - 500 million years old).

Soils in the area of the dam site appear to be primarily deposits of residual silty clays with rock fragments. The soils are of the Clarksville-Fullerton-Talbott Soil Association and have developed from thin loessial soils deposited over weathered material from cherty dolomites. The

loessial thickness map indicates that upland areas may have between 2.5 and 5.0 ft. of loess cover.

C. Foundation and Embankment Design:

No foundation or embankment design information was available. Information from the owner indicates the presence of a 15 to 20 ft. deep cutoff trench to bedrock. Bedrock was verified at the base of the cutoff by a number of borings into the rock material. A layer of bentonite was placed on the rock prior to filling the trench with clay obtained from the lake area. The remaining material for the embankment also came from the lake area. During borrowing operations, bedrock was exposed in the lake area. The owner indicated these areas were covered with a layer of compacted clay. There is apparently no particular zoning of the embankment and no internal drainage features are known to exist. No construction inspection test results are available.

D. Hydrology and Hydraulics:

The original hydraulic and hydrologic design data has been obtained from the Soil Conservation Service and is included in Appendix C. Based on a field check of spillway dimensions, embankment elevations and a check of the drainage area on U.S.G.S. quad sheets, hydrologic analysis using U.S. Army Corps of Engineers guidelines were performed and appear in Appendix C. It was concluded that the structure will pass 25 percent of the Probable Maximum Flood without overtopping. The 100-year frequency flood will not overtop the dam.

E. Structure:

The appurtenant structures associated with the dam are the drawdown pipe and primary spillway pipe. The owner reported that three anti-seep collars were installed on the 18 in. diameter spillway pipe.

2.2 CONSTRUCTION:

No construction inspection data were available. Periodic inspection during construction was performed by personnel from the SCS office in Warsaw but no records were available.

2.3 OPERATION:

No operation and maintenance records were available. Inspection indicates that maintenance of the dam (mowing the grass and brush removal) is done on a regular basis. The downstream face of the embankment has been recently mowed and grass on the embankment was well established. Some weed growth was present on the front face of the embankment. Weed growth was present around the riser pipe of the primary spillway.

2.4 EVALUATION:

A. Availability:

The engineering data available are as listed in Section 2.1. No seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

The design sheets prepared by the Soil Conservation Service, included in Appendix A and C, are valid engineering data on the design of the dam.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on 9 September 1979. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Tom Beckley P.E.- Anderson Engineering, Inc. (Civil Engineer)
Steve Brady P.E.- Anderson Engineering, Inc. (Civil Engineer)
John Healy P.E.-Hanson Engineers, Inc.(Geotechnical Engineer)
Gene Wertepny P.E.- Hanson Engineers, Inc. (Hydrologic and Hydraulic Engineer)
Dan Kerns E.I.T.- Hanson Engineers, Inc. (Geotechnical Engineer)

B. Dam:

The embankment of the dam appears to be in good condition. No sloughing of the embankment was noted. The horizontal alignment of the dam is straight. The crest of the embankment is fairly level and no surface cracking or unusual movement was obvious. Shallow auger probes into the embankment indicated the top portion of the embankment to consist of red-brown silty clay with chert fragments. Slight erosion at the west abutment and downstream embankment was noted. An erosion channel approximately two ft. wide and one foot deep was observed at the east downstream contact. No additional erosional areas were observed.

The embankment is grass covered and the crest and downstream face appear to be mowed regularly. Heavy weed growth is starting on the upstream face of the embankment. No riprap was observed except for large rock slabs on the upstream face beyond the sloped bench. The large rock slabs were in the middle third of the dam. The owner indicated that he intended to continue the placement of the large rocks the full length of the dam. No erosion was noted on the front face of the embankment. No animal burrows were detected in the embankment.

A flow of water was observed about 50 ft. downstream of the toe in the old streambed. The rate of flow was approximately three to four gallons per minute. A significant

amount of iron-oxide discoloration was noted as shown in photo nos. 22 and 23 in Appendix D. The water was coming out from underneath an earth mound formed by prior excavation work. The water was clear except for a flow that was the iron-oxide color. No sediment was noted in the water. An additional area of standing water was observed just beyond the toe of the dam between the primary spillway outlet and the two in. drawdown pipe outlet. No movement of water in this area was detected.

No instrumentation (monuments, piezometers, etc.) was observed.

C. Appurtenant Structures:

C.1 Primary Spillway:

The primary spillway consists of a 30 in. vertical riser at the front face of the embankment near the center of the dam and an 18 in. pipe through the embankment. A trash rack was installed at the top of the riser and appeared to be in good condition. On the date of inspection the pool level was approximately 12 in. below the spillway intake. Considerable weed growth was observed surrounding the spillway inlet. The owner had placed a perimeter row of concrete blocks around the riser to retain an additional four in. of pool elevation. A trickle of water was observed flowing out the downstream outlet of the spillway pipe. The apparent ingress of this water is near the spillway pipe and riser juncture. Three anti-seep collars were reportedly installed on the spillway pipe. No seepage around the pipe outlet was observed.

C.2 Emergency Spillway:

The emergency spillway located at the east abutment has never been used according to the owner. The spillway section was cut into natural ground. The spillway channel is partially covered with vegetation growth. No noticeable erosion was observed in the spillway, although erosion could result if the spillway was used regularly. The outlet channel is separated from the dam by a berm and spillway releases would not be expected to endanger the embankment.

C.3 Drawdown Pipe:

A four in. diameter pipe is located at Sta. 2+22. The pipe was used during construction to drain water from the

lake area. A four in. gate valve is located in a concrete pipe riser at the toe of the dam. A two in. gate valve was installed immediately downstream of the four in. valve where the four in. valve began to leak. It also is located in a concrete pipe riser.

D. Reservoir:

The watershed is now primarily wooded with the plans for the area to be developed into lakeside residential development. The slopes adjacent to the lake are moderate, and no sloughing or serious erosion was noted. There does not appear to be a problem with siltation.

E. Downstream Channel:

The downstream channel is lightly wooded with an established vegetation growth.

3.2 EVALUATION:

The erosion area at the east abutment-dam contact could worsen and adversely affect the stability of the dam. The seepage areas at the downstream toe should be investigated by an engineer experienced in the design and construction of dams. The heavy weed growth and concrete blocks around the primary spillway inlet can restrict flood flows. The water trickling from the primary spillway outlet should be monitored on a regular basis to detect any increase in the quantity of water flow. The above deficiencies should be corrected under the direction of an engineer experienced in the design and construction of dams.

Because the valve of the lake drain is located on the downstream side of the dam, the full head of water impounded by the dam is acting entirely through the dam. The area around the lake drain outlet should be periodically inspected for seepage which might indicate a leak or rupture of the drain pipe and could eventually initiate a piping failure through the embankment.

Photographs of the dam, appurtenant structures, the reservoir, and the watershed are presented in Appendix D.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no controlled outlet works for this dam, except for the four in. drawdown pipe which is operational but has not been used since the filling of the lake in 1975. An attempt was made by the owner to increase the pool elevation by the placement of concrete blocks around the primary spillway inlet. The spillways are uncontrolled, so that the pool is normally controlled by rainfall, runoff, evaporation, seepage, and the capacities of the uncontrolled spillways.

4.2 MAINTENANCE OF DAM:

The crest and downstream face of the dam appear to be regularly mowed. No additional maintenance procedures are regularly performed.

4.3 MAINTENANCE OF OPERATING FACILITIES:

The drawdown pipe is apparently maintained. The pipe and its associated valves appear to be in good condition.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

Weed growth and concrete blocks around the primary spillway inlet can impair flood flows. The seepage areas along the downstream toe of the dam, erosional area at the downstream dam-abutment contact, lack of erosion protection for the upstream face of the dam and leakage into the primary spillway pipe are serious deficiencies which should be corrected under the direction of an engineer experienced in the design and construction of dams.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. & B. Design and Experience Data:

The hydraulic and hydrologic analyses were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the pool and drainage areas from the U.S.G.S. quad sheet; and (3) hydrologic design sheets by the SCS. The owner indicated that the highest water level, this spring, was about one foot above the primary spillway inlet. Normally the lake level is below normal pool during the summer months. An attempt has been made to raise the pool level by placing an eight in. concrete block collar around the drop inlet structure. Our hydrologic and hydraulic analyses using U.S. Army Corps of Engineers guidelines appears in Appendix C.

C. Visual Observations:

The weed growth and concrete blocks surrounding the primary spillway inlet could restrict flood flow. The emergency spillway channel is away from the dam and spillway releases would not be expected to endanger the dam.

D. Overtopping Potential:

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 25 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the small volume of water impounded, and the height of the dam, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The structure will pass a 100-year frequency flood without overtopping.

The routing of 50 percent of the PMF through the spillways and dam indicates that the dam will be overtopped by 0.87 ft. at elevation 734.97. The duration of the overtop-

ping will be 3.75 hours, and the maximum outflow will be 875 cfs. The maximum discharge capacity of the spillways is 100 cfs. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

No structural design and construction data were able to be obtained on this dam. Construction survey notes were located in SCS files and are included in Appendix A. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

To our knowledge no post-construction changes have been made except that according to Mr. Hayes, the additional two in. gate valve was added to the drawdown pipe after construction was completed.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in good condition. Several items were noted during the visual inspection which should be corrected or controlled. These items are: (1) lack of wave protection along the entire front face of the dam; (2) heavy weed growth on front face of dam; (3) weeds and concrete block around primary spillway inlet; (4) erosion at east embankment-abutment contact; (5) seepage areas at downstream toe beyond contact; and (6) small amount of water coming out of primary spillway outlet even though there was no flow over the spillway crest. Another deficiency was the lack of seepage and stability analysis records.

The dam will be overtopped by flows in excess of 25 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to a failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on review of the information listed in Section 2.1, the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in good condition. Several items were noted during the visual inspection which should be corrected or controlled. These items are: (1) lack of wave protection along the entire front face of the dam; (2) heavy weed growth on front face of dam; (3) weeds and concrete block around primary spillway inlet; (4) erosion at east embankment-abutment contact; (5) seepage areas at downstream toe beyond contact; and (6) small amount of water coming out of primary spillway outlet even though there was no flow over the spillway crest. Another deficiency was the lack of seepage and stability analysis records.

The dam will be overtopped by flows in excess of 25 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to a failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on review of the information listed in Section 2.1, the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will

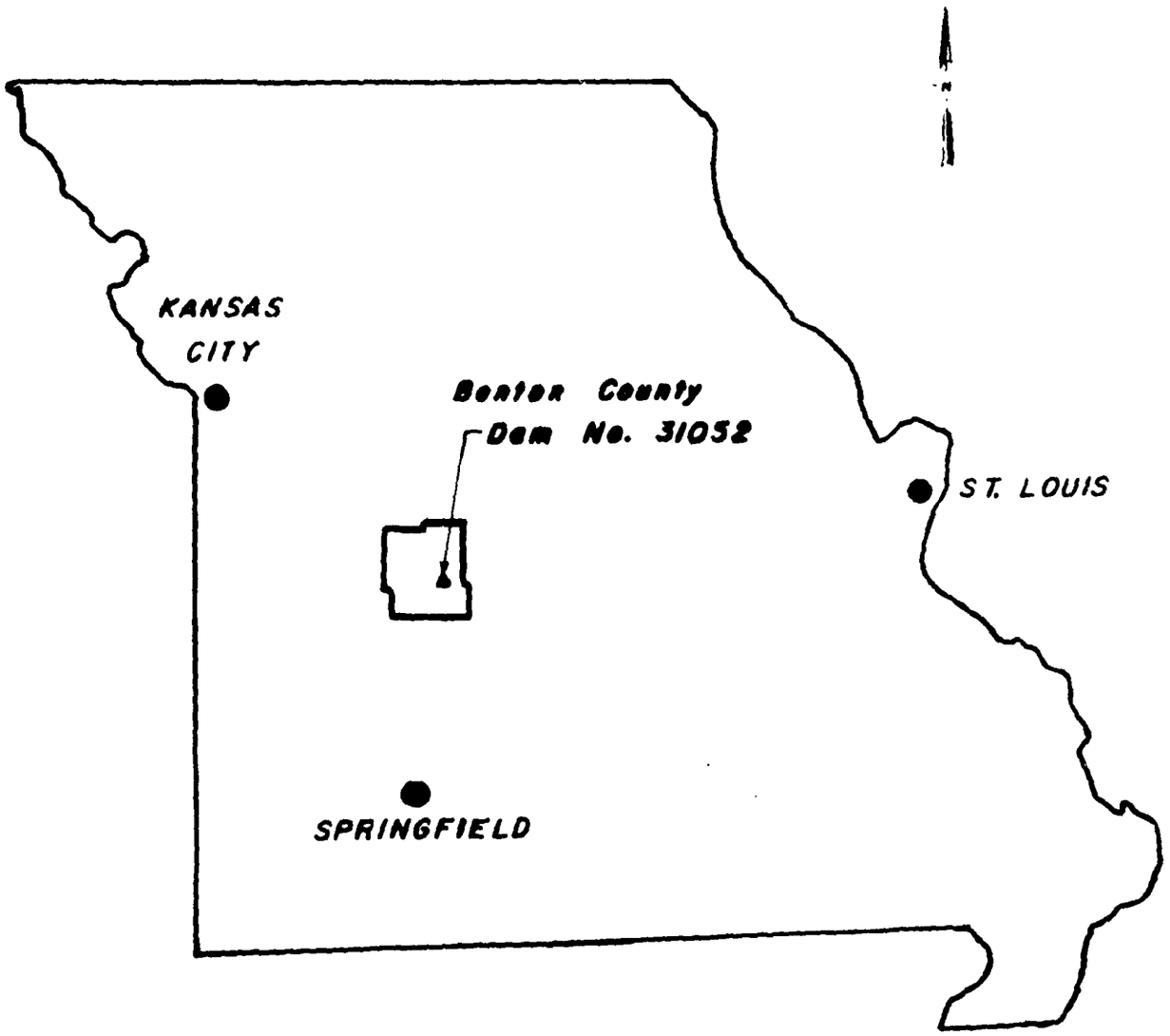
(5) The erosion areas along the dam-abutment contact should be corrected and maintained.

(6) The seepage areas at the downtream toe of the dam should be investigated by an engineer experienced in the design and construction of dams. Remedial measures may be required. As a minimum, this seepage should be monitored to determine if there is any increase in quantities and whether soil particles are being carried with the water.

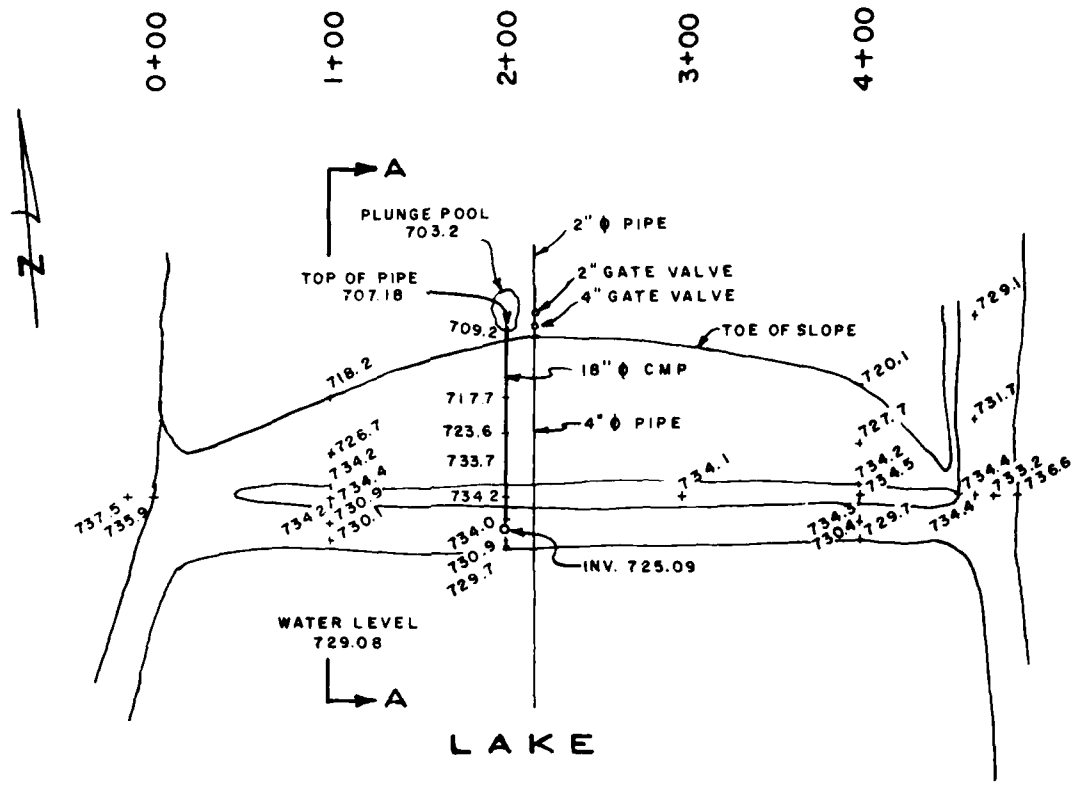
(7) The source of the water coming from the primary spillway outlet should be investigated and stopped if possible. As a minimum the flow should be checked on a regular basis for any increase in the amount or the presence of soil particles in the water.

(8) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A



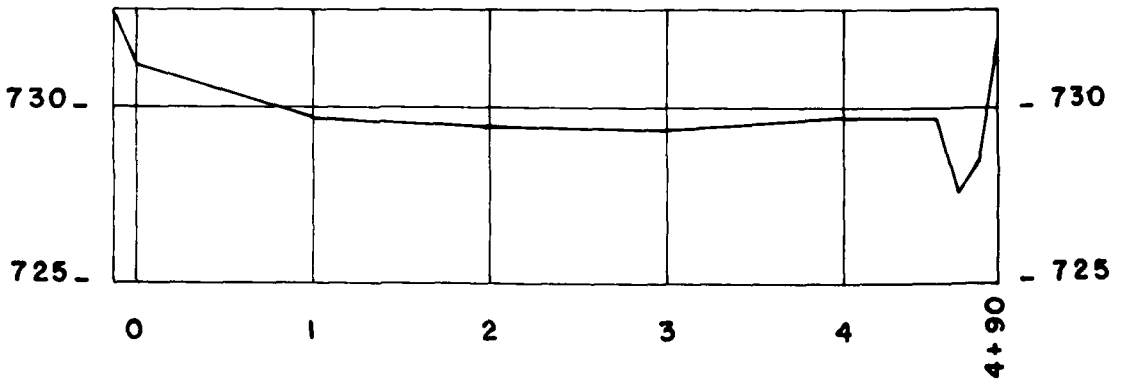
LOCATION MAP



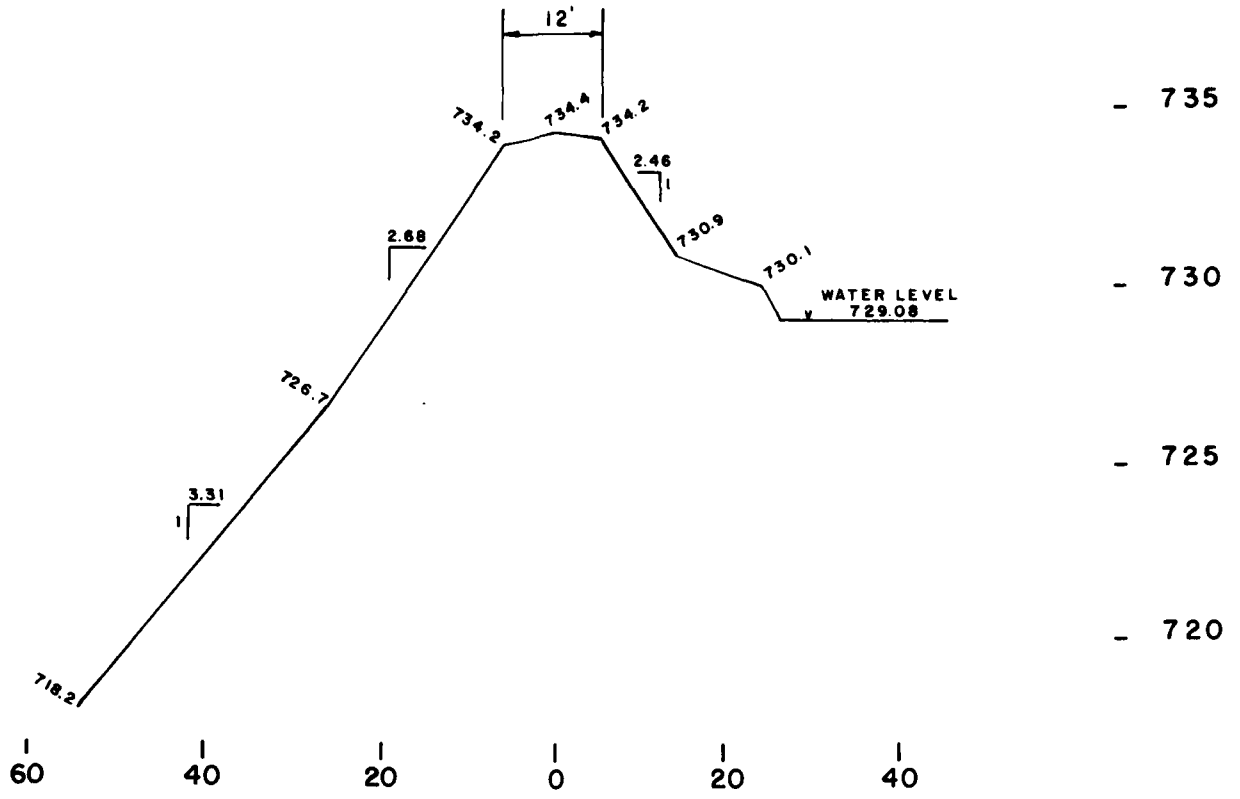
PLAN VIEW

SCALE: 1" = 100'

BENCHMARK:
TOP OF CMP RISER STA 2+00
ELEV. = 730.0 MSL



PROFILE



SECTION A-A STA 1+00

730

725

Sheet 3 of Appendix A

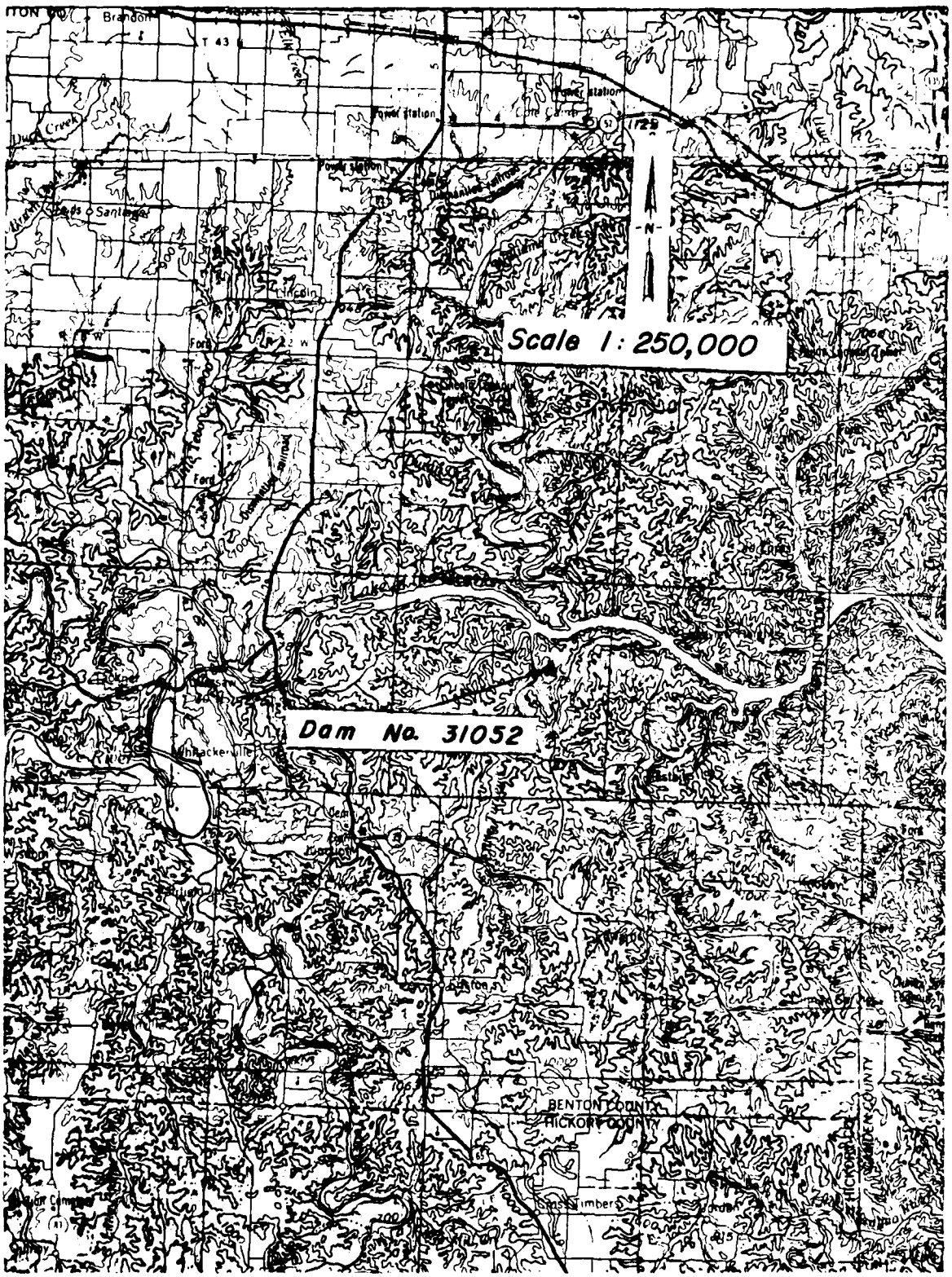
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

WILLIAM HAYES LAKE

MO. No. 31052

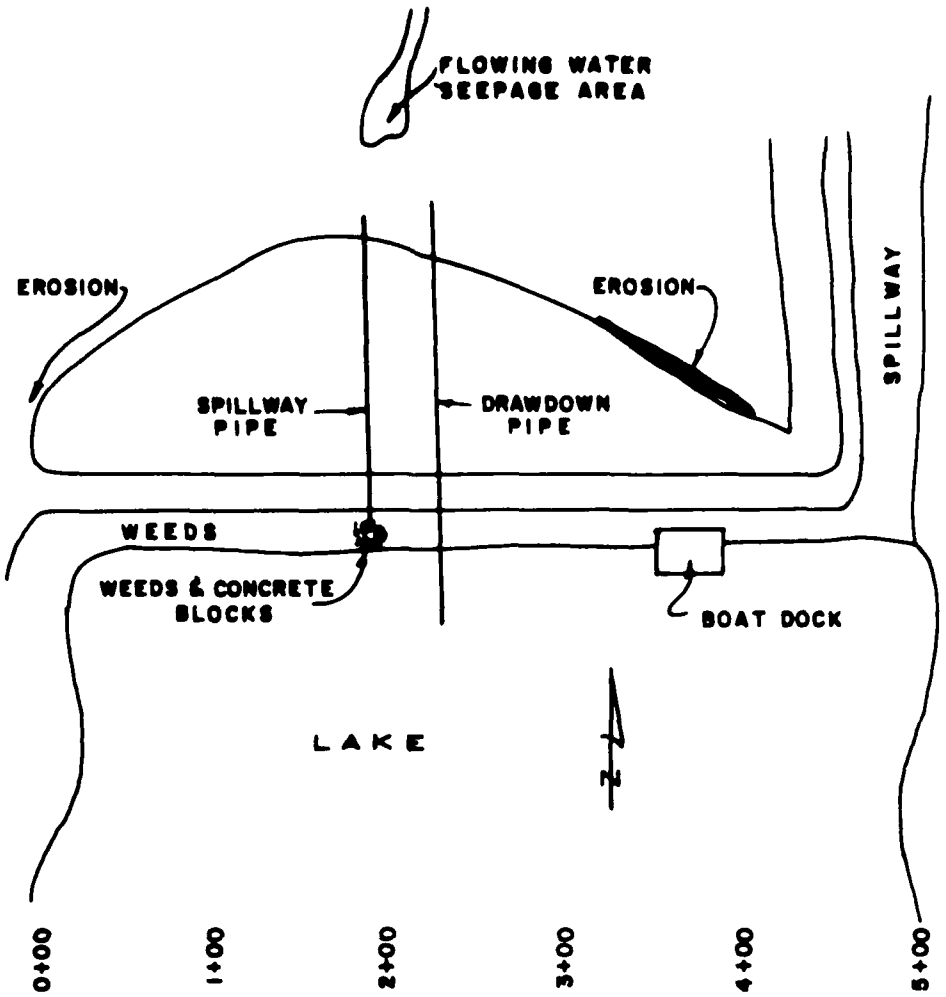
PLAN & PROFILE

BENTON COUNTY, MO.

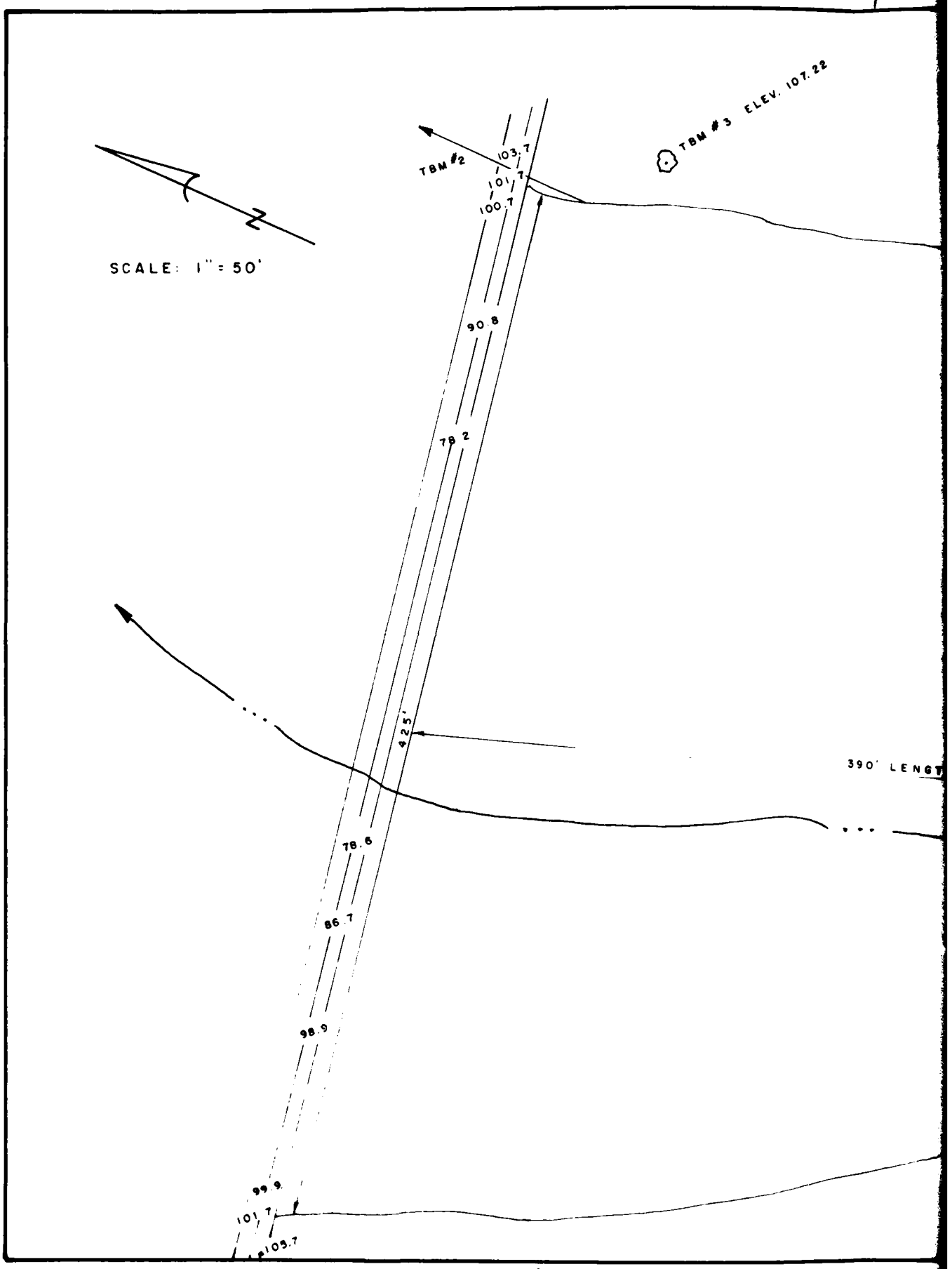


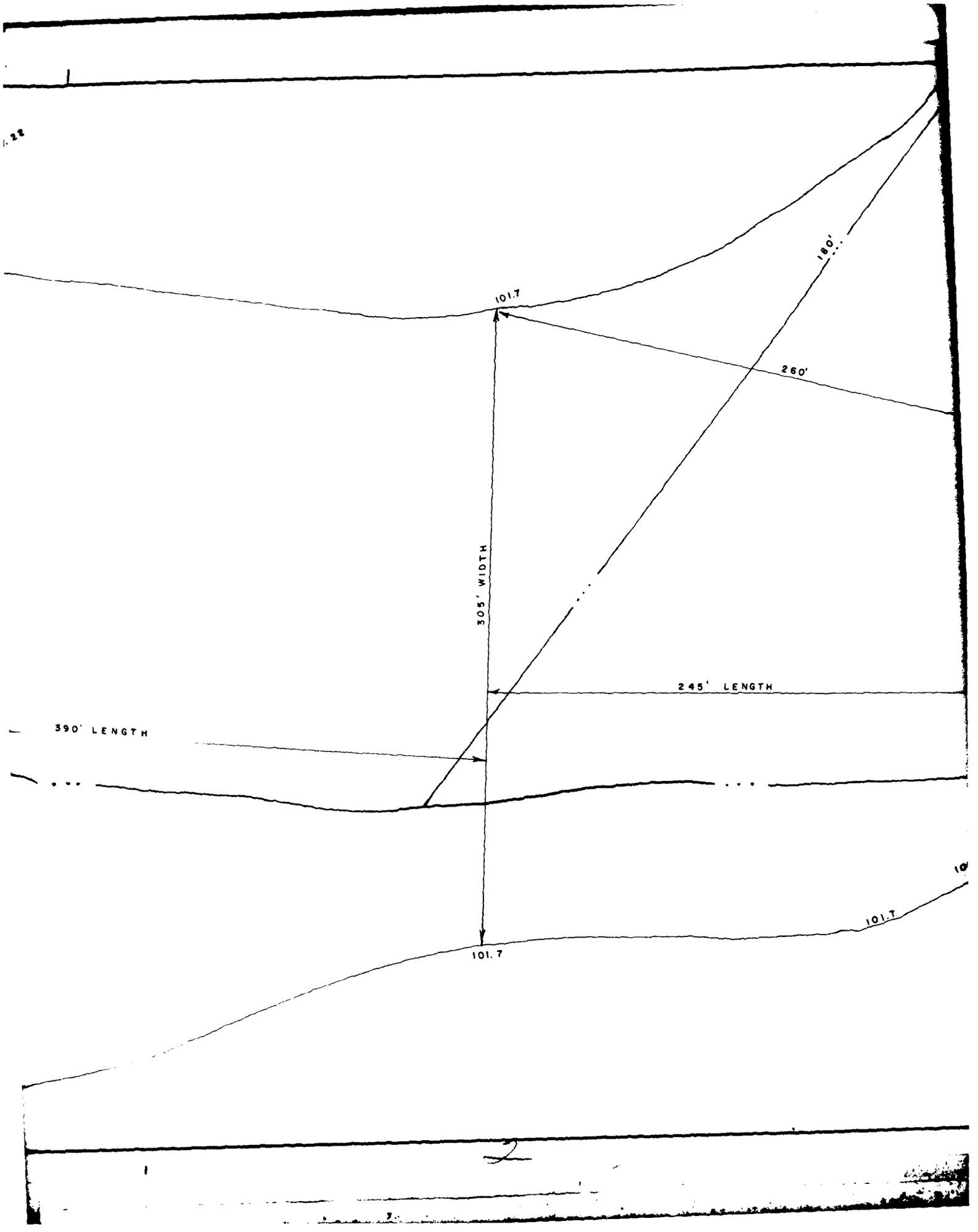
SITE VICINITY MAP

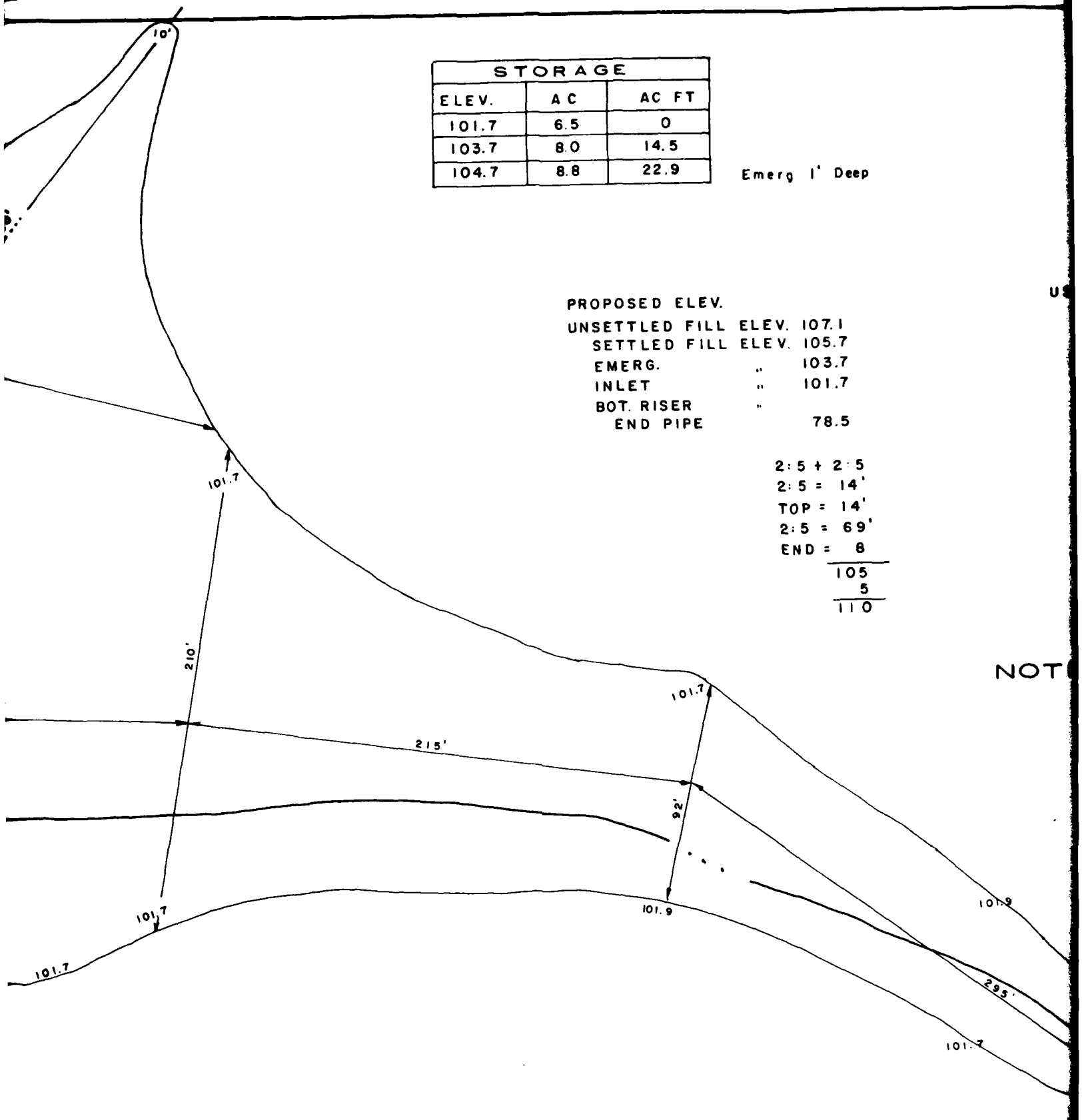
Sheet 2 Appendix A



PLAN SKETCH
INSPECTION OBSERVATION
DAM No. MO. 31052


SCALE: 1" = 50'
TBM #2
103.7
101.7
100.7
TBM #3 ELEV. 107.22
90.8
78.2
425'
390' LENGT
78.6
86.7
98.9
99.9
101.7
105.7


101.7
180'
260'
305' WIDTH
245' LENGTH
390' LENGTH
101.7
101.7



STORAGE		
ELEV.	AC	AC FT
101.7	6.5	0
103.7	8.0	14.5
104.7	8.8	22.9

Emerg 1' Deep

PROPOSED ELEV.

UNSETTLED FILL ELEV. 107.1
SETTLED FILL ELEV. 105.7
EMERG. " 103.7
INLET " 101.7
BOT. RISER "
END PIPE 78.5

2:5 + 2:5
2:5 = 14'
TOP = 14'
2:5 = 69'
END = 8
105
5
110

NOT

Emerg 1' Deep

23,565 CU. YDS. EARTH FILL

LEV.

FILL ELEV. 107.1
FILL ELEV 105.7
" 103.7
" 101.7
"

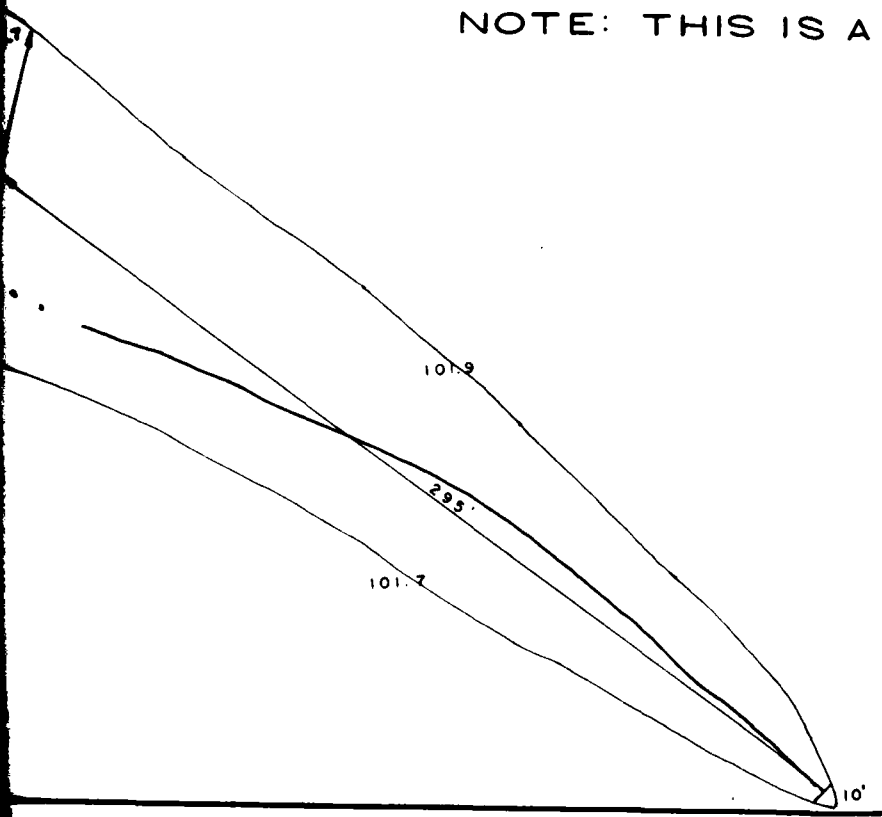
E 78.5

USED (CHECKED RISER SIZE
18" CMP
30" CMP RISER)

FOR FRONT SLOPE 2:5
BACK SLOPE = 2.5
110' - 16"

2:5 + 2:5
2:5 = 14'
TOP = 14'
2:5 = 69'
END = 8
105
5
110

NOTE: THIS IS A COPY



Sheet 5 Appendix A

ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

WILLIAM HAYES LAKE

MO. No. 31052

SURVEY NOTES
AS COPIED FROM
SCS DRAWING

BENTON COUNTY, MO.

U S Department of Agriculture
Soil Conservation Service

SCD: Wheeler Date: 5/1-14

Work Unit: 39?

Fsheds Group: Williams Draw

Location: Sec 19 T 40 R 21

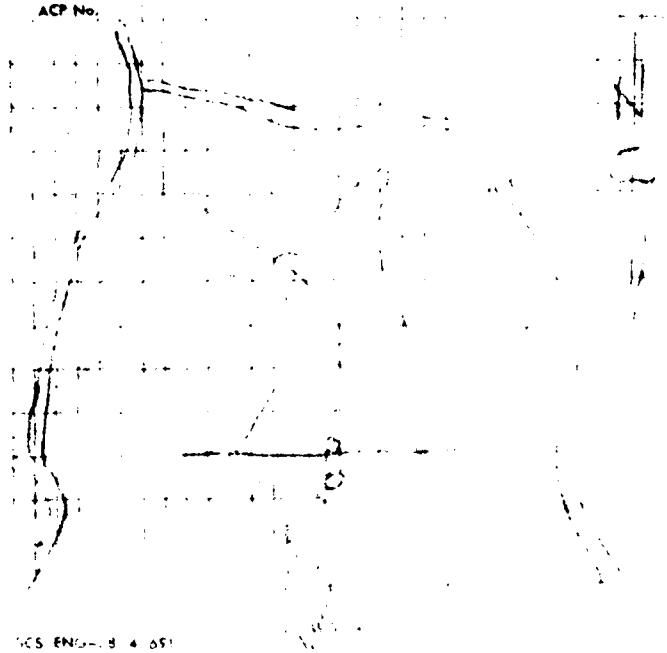
Lot:

Dsrgn Stn: Const. Layout:

Const. Check: Other:

Dist. Agt. No: Field No:

ACP No.



SCS ENG-[illegible] 4-65

Sheet 8 Appendix A

Sta.	B.S.	H.I.	F.S. or Grade Rod	Elev. or Planned Elev.	
Bm #1	7.95	1086.5		100.7	
	80°30			17	
		108.6			
Tbm #2	336°30	50	1.43	63	10722
	AZ	Beam	Rod	Dist.	
	266°45	50	49	2	
	78	50	69	10	
	78°15	42	11.9	74	3.9 E 17.8
	82	38	10.6	165	19.5 30.4 17.82
	80°20	44	12.2	297	30.0
	80°45	47	11.8	336	10.09 2.49
	83°30	49	10.7	380	7.5 4
	82	50	8.7	425	
	82	50	6.9	438	
	81°30	50	2.9	460	
[illegible]	345	50	[illegible]	338	
212 [illegible]	5.2	1049		322	
	147°	50	3.2	206	
	120	50	3.2	28[illegible]	
	338°30	50	3.0	39[illegible]	
	5[illegible]	50	2.2	72	

William Hayes
Reg. Land Surv.
3-7-74
Edmonds, Washington

T. Flanders
D. Ph. Ibsen
McEvilly
Hayes

(1)

TOP Hub with tack at E end of 12" fir stump

North 44 West side of 30' wide Dedicated Tract of land

Elev. of top of curb
Elev. at top of curb
Elev. at top of curb
Valley flow line
Elev. at top of curb
Elev. at top of curb
Elev. at top of curb

Sheet 2 Appendix A

MO-ENG-15 (Formerly MO-59 & MO-248)
5/15/69

Date 3/8/7[illegible]
By L. Finley [illegible]

U.S. DEPARTMENT OF AGRICULTURE - SOIL CONSERVATION SERVICE - COLUMBIA, MO.

EARTH WORK COMPUTATION[illegible]

Owner or Watershed William Hays

Top of Fill; Width 14'; Elev. [illegible]; Slopes Upstream 3:1 Downstream 2:1

Upstream Berm: Width 8 Elev. [illegible] Elev. ____

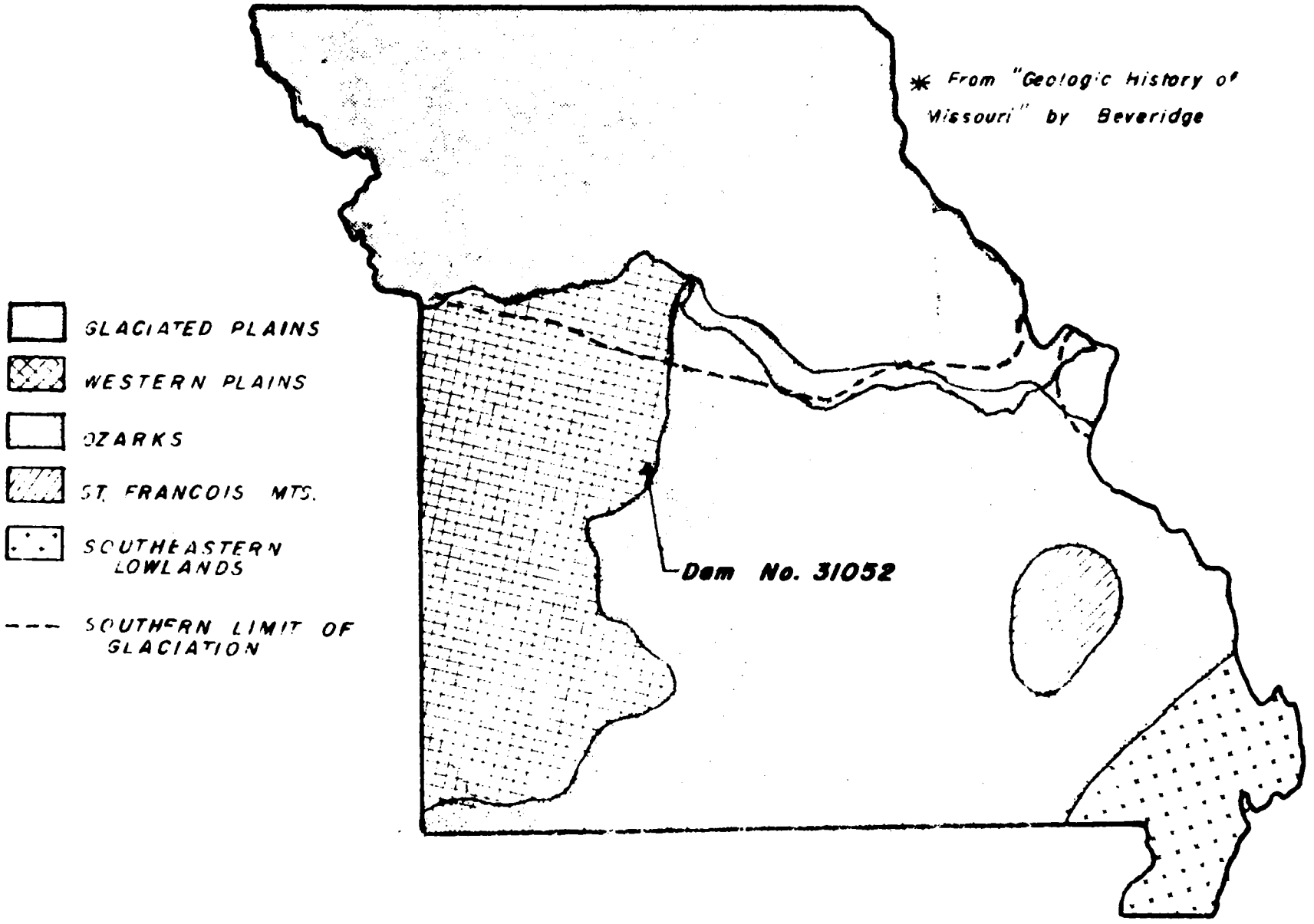
	Station	Ground Elev. at ℄	Fill Hgt. Ft.	Fill Yd.3/Ft.	Berm Hgt. Ft.	Yd 3/Ft.	Hgt. Ft.	Yd 3/Ft.	Total Fill Yd3/Ft.	Sum Fill	Dist. Between Sta.	Double Fill Yd. 3
	0+00	105.7		0	0	0			0			
22	0+22	101.7		3.6	0	0			3.6	3.6	22	79
13	0+35	99.9		6.1	1.8	0.6			6.7	10.3	13	144
45	0+80	93.9		19.0	7.8	2.1			21.1	27.8	45	1251
45	1+25	86.7		43.3	15.0	4.4			47.7	68.8	45	3096
38	1+63	78.6		82.1	25.1	6.8			88.9	136.6	38	5191
135	2+98	78.2		84.3	23.5	7.2			91.5	180.4	135	24354
88	3+86	90.8		28.3	10.9	3.0			31.3	122.8	88	10806
57	4+43	100.7		4.9	1.0	0.3			5.2	36.5	57	2081
7	4+50	101.7		3.6	0	0			3.6	8.8	7	62
13	4+63	103.7		1.4	0	0			1.4	5.0	13	65
							Total Double Fill					47129
							Total Fill					23565

Allow ____ % for Settlement . ____
Side Spillway Fill (Including Dikes) ____
Backfill Core Trench Exc. . . . . . ____
Backfill Structure Exc. . . . . ____
Backfill Strippings. . . . . ____
[illegible] Total [illegible] ____

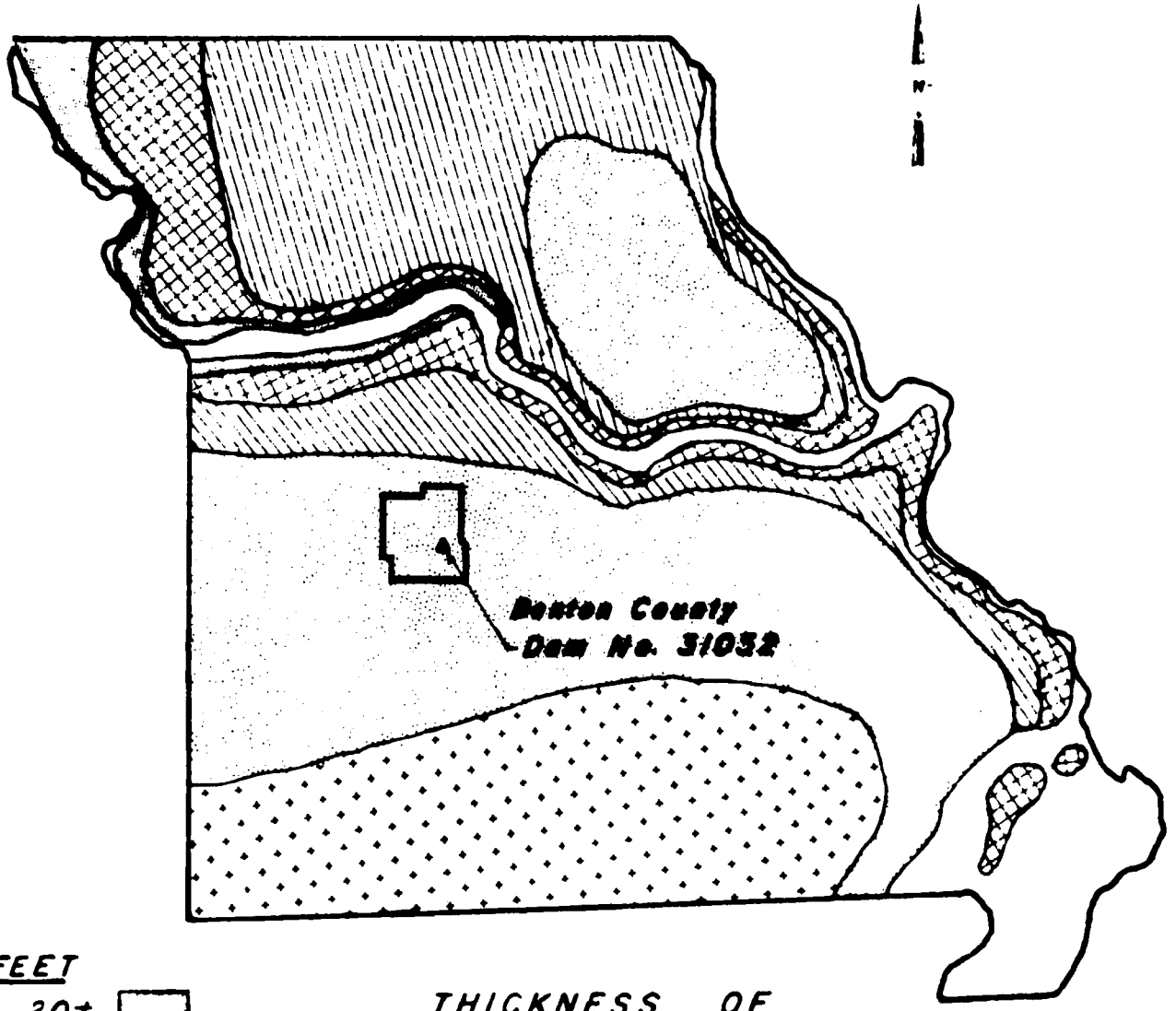
[illegible] Appendix A

APPENDIX B

MAJOR GEOLOGIC REGIONS OF MISSOURI



* From "Soils of Missouri"



FEET

20+

10 - 20

5 - 10

2.5 - 5

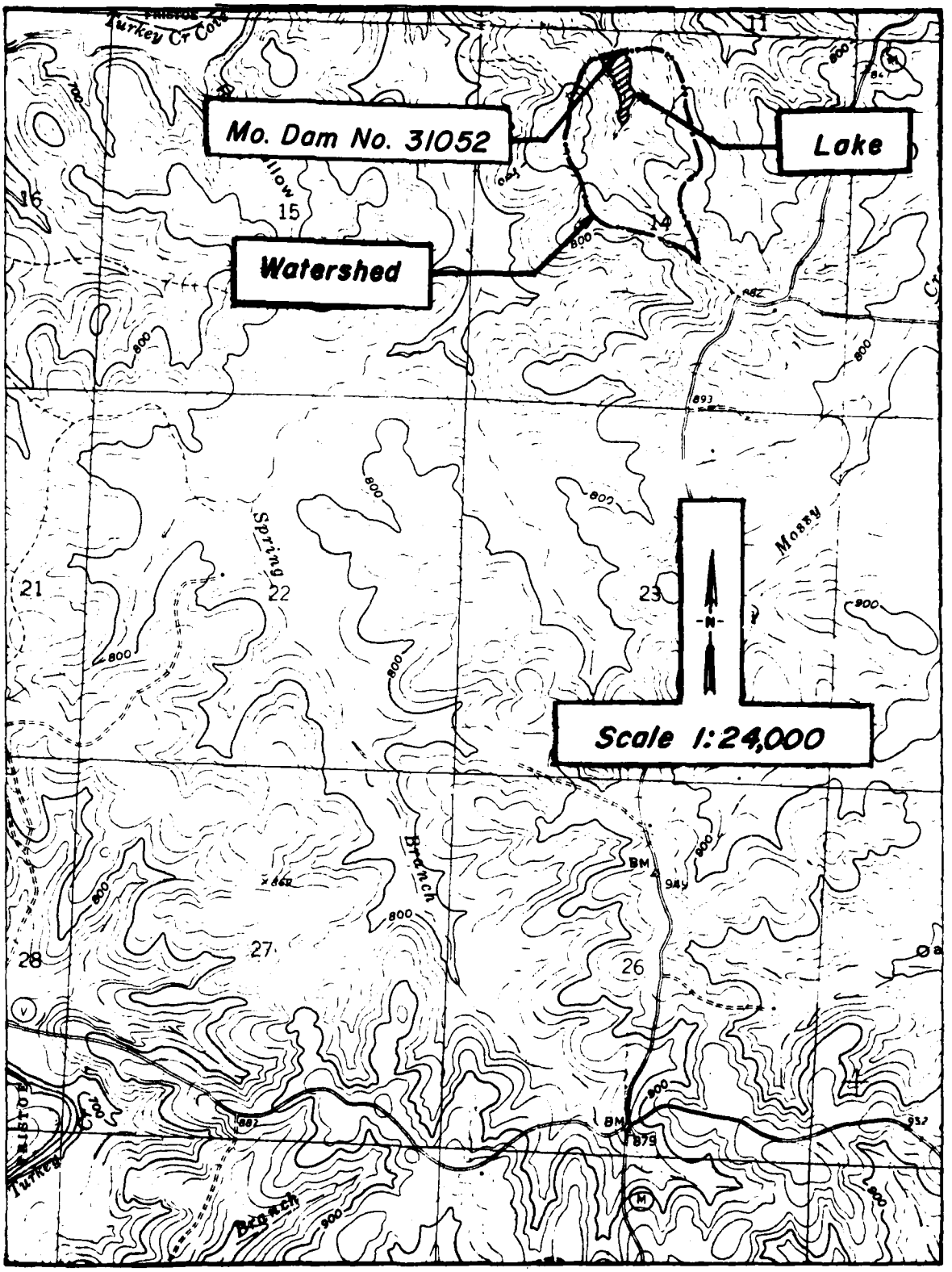
2.5 -

THICKNESS OF LOESSIAL DEPOSITS

SHEET 2 OF APPENDIX B

APPENDIX C

From Edwards, Mo. 7.5 Quad



LAKE AND WATERSHED MAP

Sheet 1 Appendix C

HYDRAULICS AND HYDROLOGIC DATA

Design Data: From Field Measurements and Computations

Experience Data: No records are available. The owner indicated that the highwater, this spring, was about one foot above the primary spillway inlet. Normally the lake level is below normal pool during the summer months. An attempt has been made to raise the pool level by placing an eight in. concrete block collar around the drop inlet structure.

Visual Inspection: At the time of inspection, the pool level was approximately 0.9 ft. below normal pool.

Overtopping Potential: Flood routings were performed to determine the overtopping potential. The watershed and the reservoir surface areas were obtained by planimeter from the U.S.G.S. Edwards, Missouri 7.5 minute quadrangle map. The storage volume was developed from this data. A 5 minute interval unit graph was developed for the watershed, which resulted in a peak inflow of 484 c.f.s. and a time to peak of 8.4 minutes. Application of the probable maximum precipitation, minus losses resulted in a flood hydrograph peak inflow of 1988 c.f.s. Rainfall distribution for the 24 hour storm was according to EM 1110-2-1411.

Based on our analyses, the combined spillways will pass 25 percent of the Probable Maximum Flood (PMF). The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that the structure (small size with high downstream hazard potential) pass 50 to 100 percent of the PMF, without overtopping. Considering the small volume of water impounded and the height of the dam , 50 percent of the PMF has been determined to be the appropriate spillway design flood.

The routing of the 50 percent of the PMF through the spillways and dam indicates that the dam will be overtopped by 0.87 ft. at elevation 734.97. The duration of the overtopping will be 3.75 hours, and the maximum outflow will be 875 c.f.s. The maximum discharge capacity of the combined spillways is 100 cfs. Analysis of the data indicates that the 100-year frequency flood will not overtop the dam. The computer input, output and hydrograph for 50 percent of the PMF are presented on Sheets 5, 6 and 7 of this Appendix C.

OVERTOPPING ANALYSIS FOR WILLIAM HAYES LAKE DAM

INPUT PARAMETERS

1. Unit Hydrograph - SCS Dimensionless - Flood Hydrograph Package (HEC-1); Dam Safety Version Was Used.
   Hydraulic Inputs Are as Follows:

   a. Twenty-four Hour Rainfall of 25.7 Inches for 200 Square Miles - All Season Envelope

   b. Drainage Area = 92 Acres; = 0.14 Square Miles

   c. Travel Time of Runoff 0.16 Hrs.; Lag Time 0.10 Hrs.

   d. Soil Conservation Service Soil Group B

   e. Soil Conservation Service Runoff Curve No. 78 (AMC III)
   Soil Conservation Service Runoff Curve No. 60 (AMC II)

   f. Proportion of Drainage Basin Impervious 0.08

2. Spillways

   a. Primary Spillway: 30 inches I.D. CMP (Riser) and 18 inches I.D. CMP (Outlet Pipe)

   b. Emergency Spillway: Trapezoidal Channel
   Length 13 ft.; Side Slopes 3.25:1 & 5:1; C=Varies

   c. Dam Overflow

   Length 360 ft.; Crest El. 734.1; C = Varies

3. Spillway and Dam Rating:

   Curve Prepared by Hanson Engineers. Data Provided to Computer on Y4 and Y5 Cards. (See sheet 5 Appendix C)

   Formula and Method Used:
   Primary Spillway: Charts for entrance and outlet control in CMP pipes.
   Equation Used for Emergency Spillway: $\frac{Q}{g}^2 = \frac{A}{T}^3$

Note: Time of Concentration From Equation $Tc = \frac{(11.9\ L^3)^{.385}}{(H)^{.385}}$

Sheet 3 Appendix C

California Culvert Practice, California Highways and Public Works, September, 1942.

SUMMARY OF DAM SAFETY ANALYSIS

1. Unit Hydrograph

   a. Peak - 484 c.f.s.

   b. Time to Peak 8.4 Min.

2. Flood Routings Were Computed by the Modified Puls Method

   a. Peak Inflow

      50% PMF 994 c.f.s.; 100% PMF 1988 c.f.s.

   b. Peak Elevation

      50% PMF 734.97; 100% PMF 735.49

   c. Portion of PMF That Will Reach Top of Dam

      25%; Top of Dam Elev. 734.1 ft. (Lower Point)

Computer Input and Output Data are shown on the following sheets of this Appendix.

```
A       OVERTOPPING ANALYSIS FOR WILLIAM HAYES LAKE DAM
A       STATE ID NO. 31052  CO. NO. 015  CO. NAME BENTON
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 79511
B    300                5
B1     5
J      1       7       1
J1   .15     .20     .30     .40     .50     .75     1.0
K      0       1                               3       1
K1      INFLOW HYDROGRAPH COMPUTATION **
M      1       2    0.14            0.14       1                       1
P      0    25.7     102     120     130
T                                                   -1      -78             0.08
W2  0.16    0.10
X      0    -.1       2
K      1       2                       0       4       1
K1      RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                               1       1
Y1     1                                        53.7      -1
Y4   730     731   732.4     733   734.1     735     736     737
Y5     0      18      21      31     100     224     425     665
$A     0     5.9     9.2
$E 702.7     730     740
$$   730
$D 734.1
$L     0     125     275     361     394     428     454     459     462     466
$V 734.1   734.2   734.4   734.5   735.0   735.5   735.9   736.5   737.0   737.5
K     99
```

P.M.F. Input Data
Sheet 5, Appendix C

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7
				0.15	0.20	0.30	0.40	0.50	0.75	1.00
HYDROGRAPH AT	1	0.14	1	298.	398.	596.	795.	994.	1491.	1988.
	(	0.36)	(	8.44)(	11.26)(	16.89)(	22.51)(	28.14)(	42.21)(	56.29)(
ROUTED TO	2	0.14	1	37.	72.	345.	670.	875.	1379.	1876.
	(	0.36)	(	1.04)(	2.04)(	9.78)(	18.97)(	24.78)(	39.04)(	53.13)(

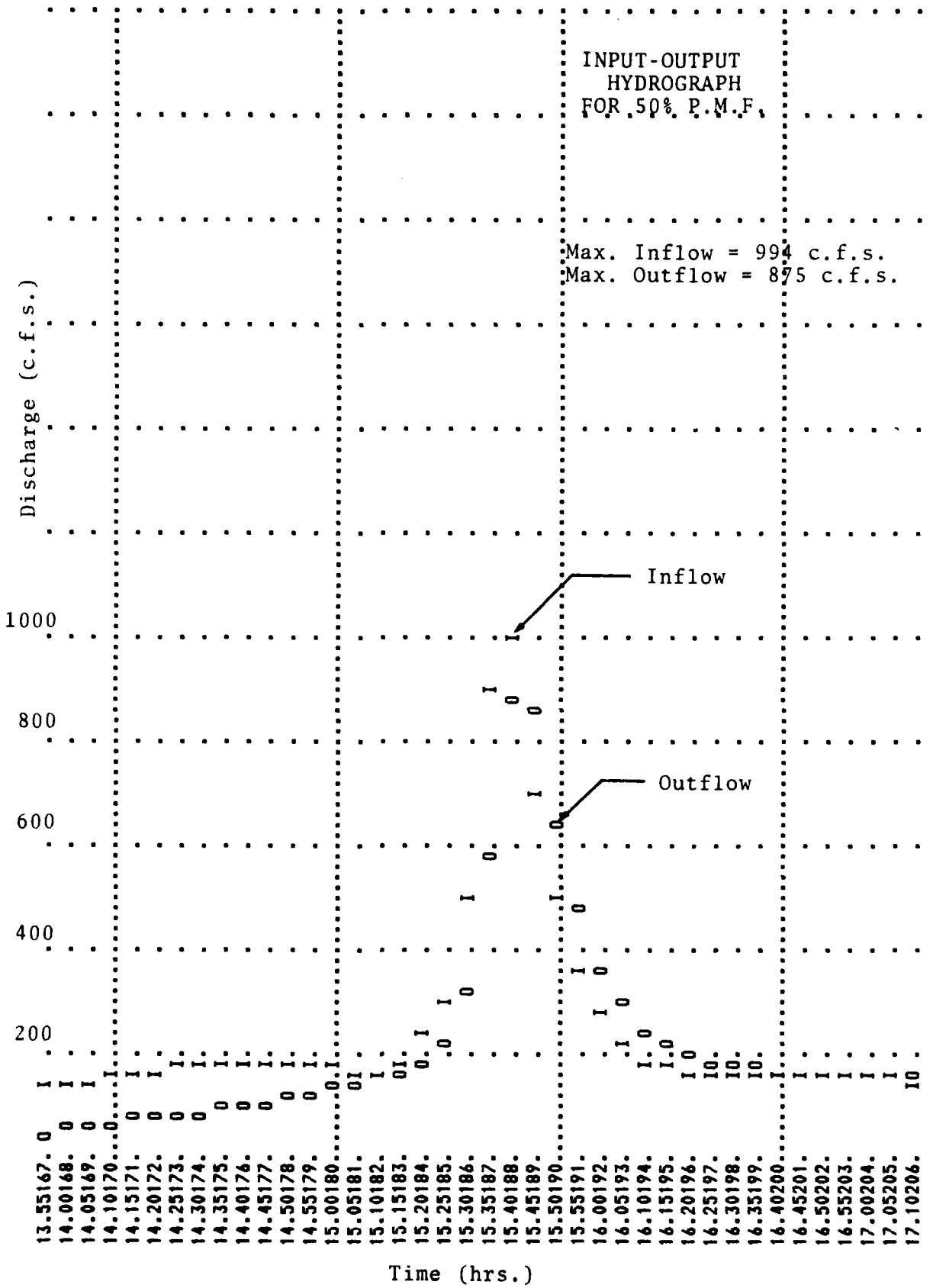
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	730.00	730.00	734.10
STORAGE	54.	54.	80.
OUTFLOW	0.	0.	100.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.15	733.09	0.00	73.	37.	0.00	18.00	0.00
0.20	733.66	0.00	77.	72.	0.00	16.17	0.00
0.30	734.57	0.47	84.	345.	1.58	15.83	0.00
0.40	734.83	0.73	86.	670.	2.75	15.75	0.00
0.50	734.97	0.87	87.	875.	3.75	15.67	0.00
0.75	735.25	1.15	89.	1379.	5.42	15.67	0.00
1.00	735.49	1.39	91.	1876.	6.42	15.67	0.00

P.M.F. Output Data
Sheet 6, Appendix C



Sheet 7, Appendix C

MO-ENG-40
12/70
(File Code: ENG-13)

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DESIGN SHEET FOR CLASS I, ~~II~~, ~~V~~ * DETENTION STORAGE STRUCTURE
WITH DROP INLET SPILLWAY -- ~~PORT INLET SPILLWAY~~ -- ~~CANOPY INLET SPILLWAY~~ *

Landowner Hillman Mfg. Co. County Barton Co

Design by L. Hawkins Date 3-8-74 Checked by _____ Date _____

Drainage area = 85 ac. Height x storage = _____ x _____ = _____

WATERSHED CONDITIONS AND FACTORS

Location factor: L = 1.0

Infiltration factor: (~~above~~) average (~~below~~)* I = 1.0

Topographic factor: 8 % average slope T = 1.0

Shape factor: runoff distance = 2900 ft. S = 1.0

Cover factor: cropland ____ %, pasture ____, timber 100 V = 0.9

Contouring factor: C = 1.0

Storage factor: ____ terraced P = 1.0

PEAK RATE OF RUNOFF AND VOLUME OF RUNOFF

Product of factors = L x I x T x S x V x C x P [illegible] c.f.s.

V x I = .9 x 1.0 = .9

For Principal Spillway Design:

25 -year peak rate of runoff = Q_{pp} = 1.5 x [illegible] c.f.s. = 252 c.f.s.

Rate of volume of runoff = .18 ac. ft./ac. (Table 1, ISIM)

Total volume of runoff = V_{rp} = drainage area x (rate of volume of runoff) x L =

85 ac. x .18 ac. ft./ac. x 1.0 = 15.30 ac. ft.

For Both Spillways (total structure):

50 -year peak rate of runoff = Q_r [illegible] c.f.s. = 378 c.f.s.

Rate of volume of runoff = .21 ac. ft./ac.

Total volume of runoff = V_r = 85 ac. x .21 ac. ft./ac. x 1.0 = 17.85 ac. ft.

* Mark out those items that do not apply.

Instructions for use of form: Make one pencil copy for each applicable structure. File with other worksheets and structure plan in landowner's folder in field office.

Sheet 2 Appendix C

PRINCIPAL SPILLWAY DESIGN

Available storage at stage of 2.0 ft = V_{sp} = 14.5 ac. ft. (See map)

V_{sp}:V_{rp} = 14.5 ac. ft. : 15.3 ac. ft. = .95 Q_{op} : Q_{ip} = 0.03 (Table 2, 1519)

Q_{op} = Q_{ip} x 0.03 = 257 c.f.s. x .03 = 7.56 / 7.6 c.f.s.

Conduit.

Type SIF Length = 98 ft. Total head on conduit = 24.4 ft.

Diameter = 16 in. Discharge capacity = 25 c.f.s. (1520)

Minimum entrance head = 8.0 ft. (1510 or 1511) 16"/31 - 235 24.4 ft.

Riser: **

Type SI Riser Height = [illegible] Diameter = [illegible] in. (1511)

EMERGENCY SPILLWAY DESIGN

Control Section:

Depth of flow = 1.0 ft. V_s at this depth = 229 ac. ft. (See map)

V_s : V_r = 229 ac. ft. : 1785 ac. ft. = 1+

Q_{op} : Q_1 = 25 c.f.s. : 378 c.f.s. = .07 Q_{oe} : Q_1 = _____ (Table 3, 1519)

Q_{oe} = Q_1 x _____ = _____ c.f.s. x _____ = _____ c.f.s.

Width = 25 ft. Total depth = depth of flow + freeboard = 1.0 ft. + 1.0 = 2.0 ft. Use 2.0 ft. (Table 4, 1517)

Exit Section:

Slope = _____% Quality of vegetation: (fair) (good) (excellent) *

(Less) (More) * erosive soils. Permissible velocity = _____ f.p.s. (1517)

Depth = _____ ft. Design velocity = [illegible] = _____ ft. (1517 or 1505)

Use width of _____ ft.

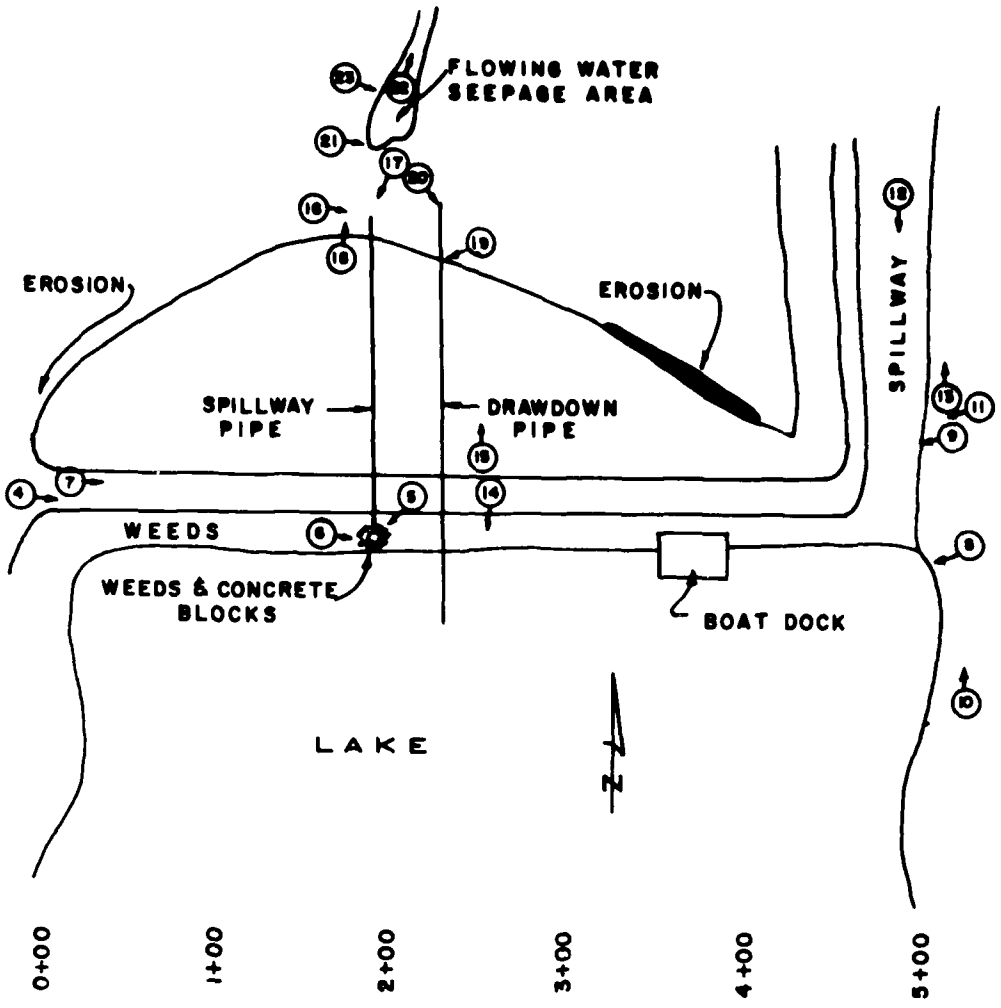
ANTI-SEEP COLLARS

Length of saturated zone = L = _____ ft. [illegible] = _____ ft. (1515)

Number = n = (L x _____) : V = (_____ x _____) = _____. Use _____ collars.

* Mark out those items that do not apply.
** Applies only to Drop Inlet Spillways.

APPENDIX D



PLAN SKETCH
KEY TO PHOTOGRAPHS
DAM No. MO. 31052

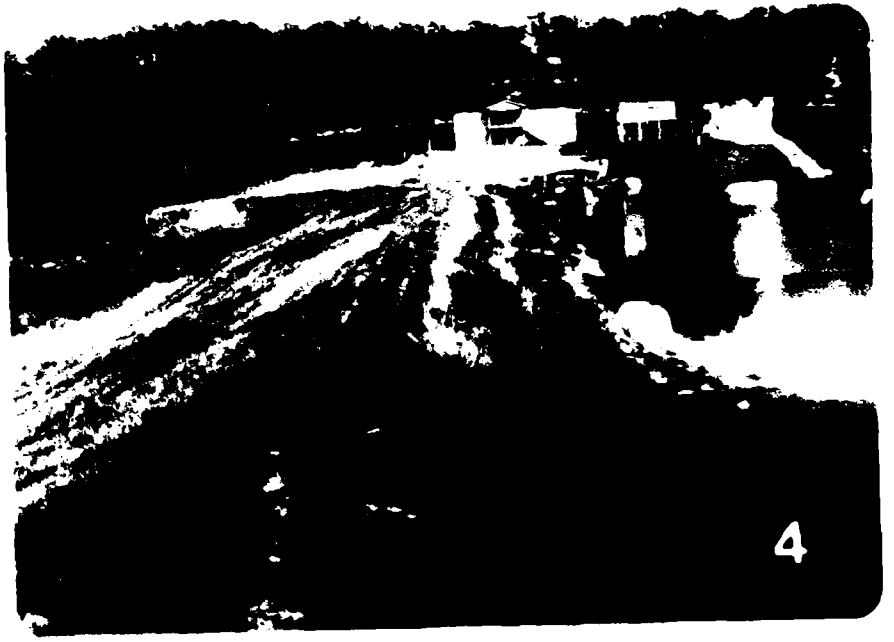
INDEX TO PHOTOGRAPHS

Photo No.	
1.	Aerial - Lake and Dam, Looking South
2.	Aerial - Lake and Dam, Looking West
3.	Aerial - Dam and Emergency Spillway - Note Erosion at Toe of Embankment
4.	Crest of Dam - Looking East
5.	Primary Spillway Inlet - Note Weed Growth
6.	Primary Spillway Inlet - Note Weed Growth and Concrete Blocks
7.	Crest and Downstream Face - Looking East
8.	Upstream Face - Looking West
9.	Downstream Face - Looking West
10.	Emergency Spillway - Looking North
11.	Emergency Spillway - Looking Southwest
12.	Emergency Spillway - Looking South
13.	Downstream Channel - Looking North
14.	Lake - From Crest of Dam
15.	Downstream Floodplain - Looking North
16.	Primary Spillway Outlet
17.	Primary Spillway Outlet
18.	Downstream Floodplain-Primary Spillway Outlet
19.	Drawdown Valve - Overhead View
20.	Drawdown Pipe Outlet
21.	Seepage Area - 50 Feet Downstream of Toe
22.	Flowing Water from Seepage Area - Note Discoloration
23.	Flowing Water from Seepage Area


1


2


3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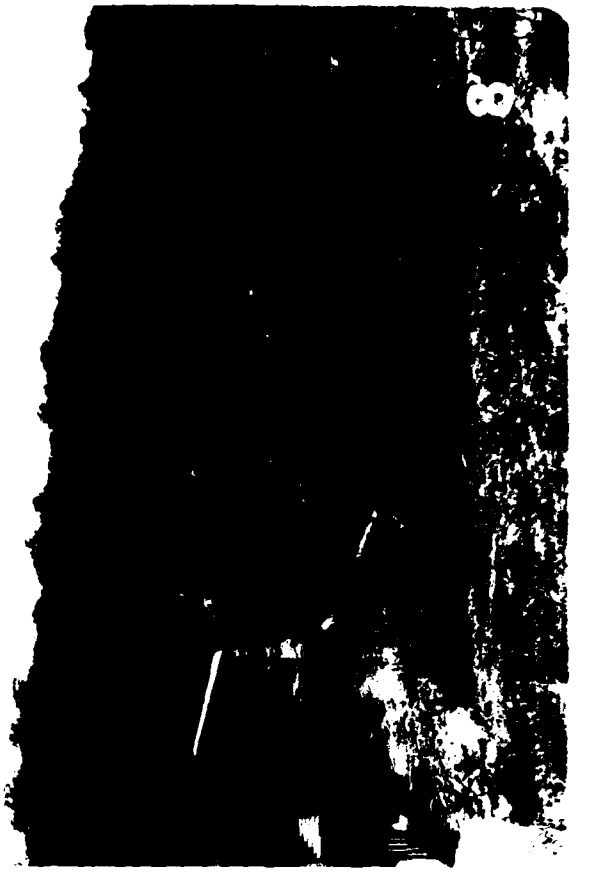


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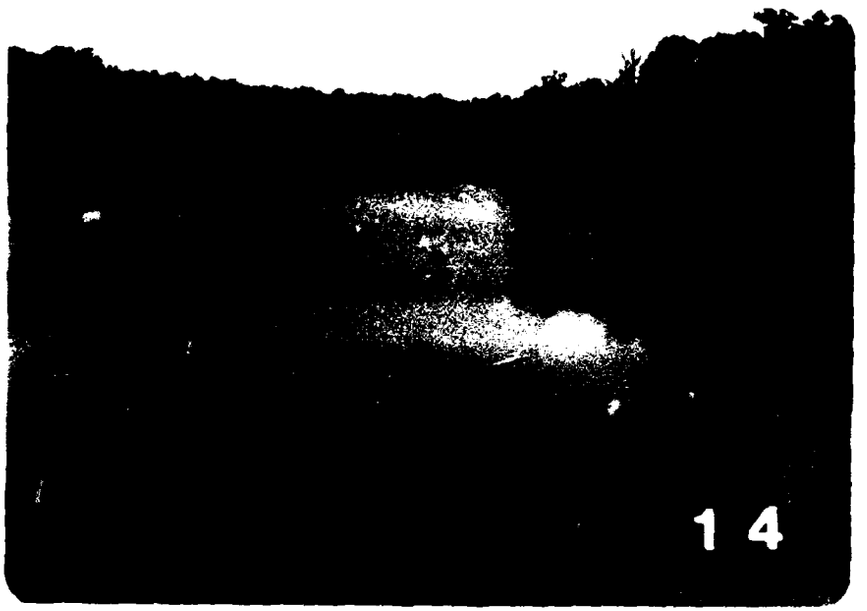
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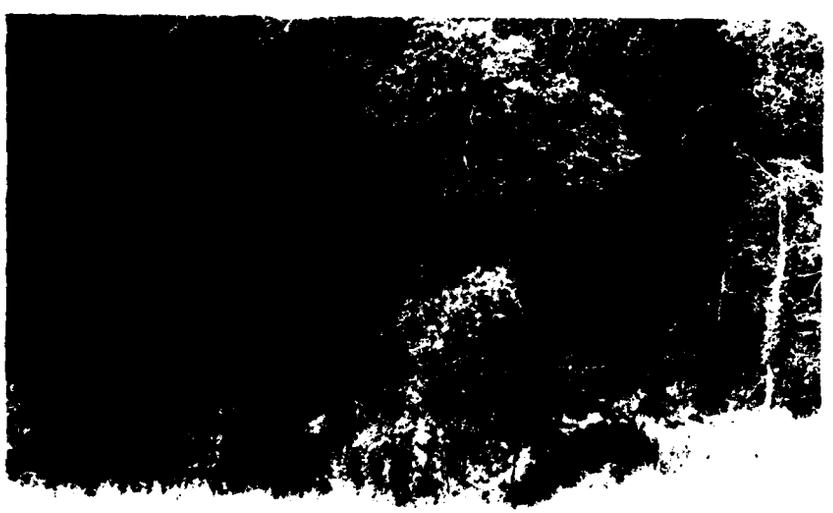


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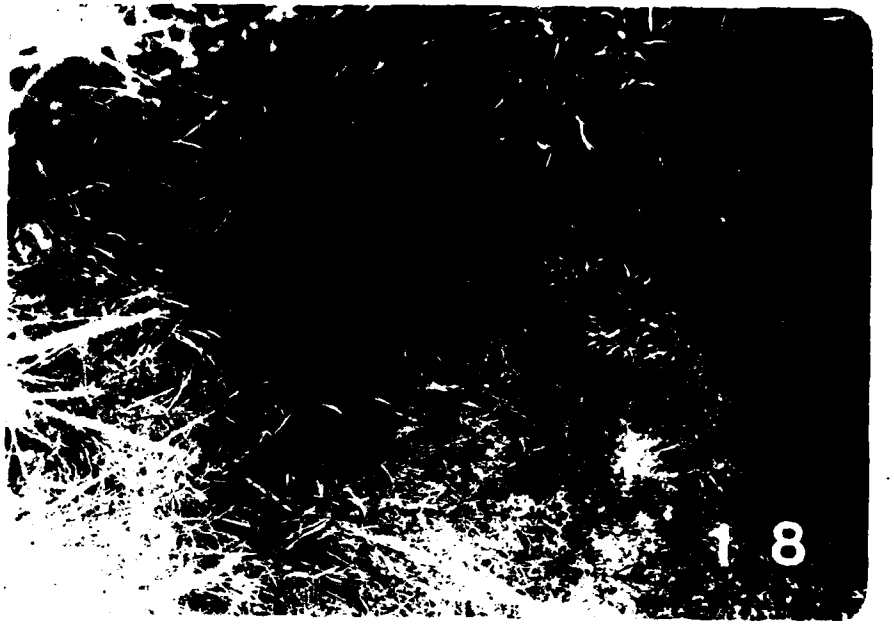
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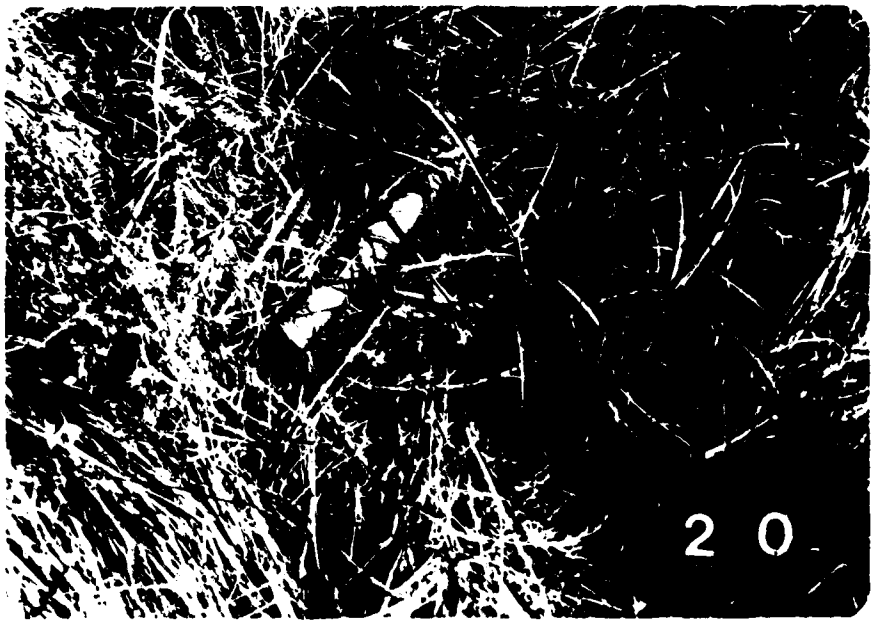
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